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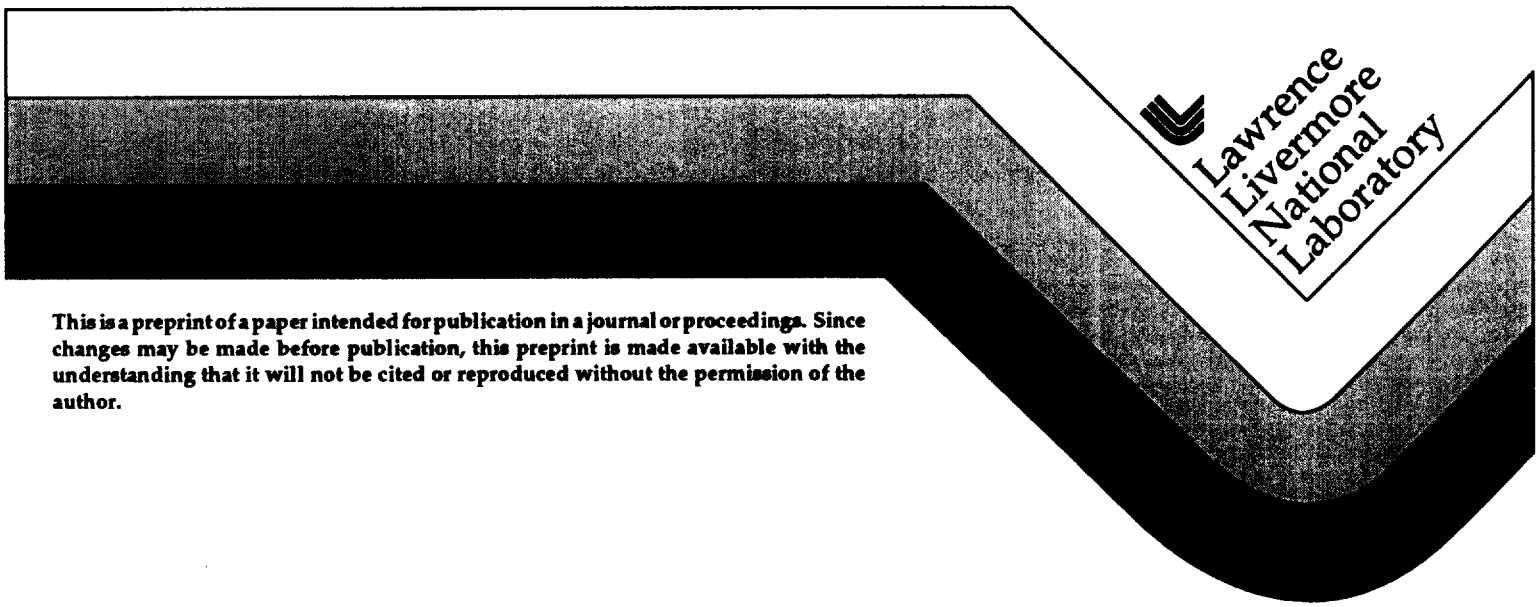

Recent Developments in Fissile Material Exemptions for Shipping Packages

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SUMMARY

This paper discusses the regulatory exemptions for shipping packages that contain limited amounts of fissile material and concerns that have arisen over the adequacy of these regulations. The results of an ongoing review of these exemptions by the various regulatory agencies will be presented in the session.

BACKGROUND

Regulations for the transportation of radioactive material, e.g., 10 CFR Part 71 and 49 CFR Part 173, establish special requirements for shipping packages that contain fissile material. As defined by these regulations, fissile material includes ^{233}U, ^{235}U, ^{238}Pu, ^{239}Pu, ^{241}Pu, or any combination of these nuclides.

To avoid overly burdensome controls on packages that do not have a criticality concern, three special exceptions are identified in the regulations. First, the definition of fissile material itself specifically excludes unirradiatied natural and depleted uranium, or natural and depleted uranium that have been irradiated in a thermal reactor. Second, certain packages—even though they contain some fissile material—are exempt from the fissile material controls. Such packages contain small quantities, dilute concentrations, or low enrichments of fissile material. Third, under certain provisions, general licenses permit the shipment of fissile material in packages that do not need to meet the full set of standards typically required for shipment of fissile material. These provisions are also for small quantities, dilute concentrations, or low enrichments of fissile material, similar to packages that are fissile exempt.

This paper will specifically address fissile exempt packages, although for the most part similar issues are also applicable to the other exceptions listed above.

REGULATIONS (OCTOBER 1996)

At the time this paper was prepared (early October 1996), packages that contained the following fissile material were exempt from fissile material controls, as indicated in 10 CFR 71.53 and 49 CFR 173.453:

(1) No more than 15 grams of fissile material,

(2) Hydrogenous solutions or mixtures with an H/X of at least 5200, a fissile concentration of no more than 5 grams per liter, and a maximum fissile mass of 500 or 800 g (depending on the nuclides present),

(3) No more than 5 g of fissile material in any 10 liter volume,

(4) Homogenous mixtures of uranium enriched to no more than 1% ^{235}U by weight (plutonium and ^{233}U content limited to 1% of ^{235}U mass),

(5) Liquid solutions of uranyl nitrate enriched to no more than 2% ^{235}U by weight (plutonium and ^{233}U content limited to 0.1% of ^{235}U mass), or

(6) No more than 1 kg of Pu, provided the mass of ^{239}Pu and ^{241}Pu does not exceed 20%.

CONCERNS

During the past several years, concerns have arisen over these fissile material exemptions. Criticality personnel have postulated a number of situations in which the above limits could be satisfied with packages in a critical or nearly critical configuration. Such concerns generally fall into one of three categories.

Mass Limits. Exemptions based on mass have been challenged by considering a very large number of very small packages. The minimum dimension of a package for shipment of radioactive material is only 10 cm. Package dimensions might be further reduced as the result of hypothetical accident conditions. Exemptions (1) and (2) above do not depend on package size.

Concentration/Enrichment Limits-Low Absorption Moderation. Several of the fissile exemptions listed above are similar to, or even more restrictive, than typical subcritical limits for aqueous solutions reflected by water. For example, a concentration of 5 g/10 liters is well below the necessary concentration to achieve criticality with an aqueous solution of either uranium or plutonium. Certain other moderating materials, however, have absorption cross sections smaller than those of (light) water. Provided the system is large enough to reduce leakage, mixtures or solutions with significant quantities of deuterium, beryllium, or carbon (without hydrogen) can be critical with concentrations of fissile material less than 0.5 g/liter. Likewise, uranium enrichments less than 1% can also achieve criticality with such low absorbing materials.

Concentration Limits-Low Density Moderation. As noted in the previous situation, the fissile exemption because of low concentration is based on absorption by other than fissile materials. If the density of these other materials is also very low (and the system large enough to overcome leakage), a critical reaction is also in principle achievable. For example, in an infinite homogeneous system, the multiplication factor depends on the relative densities of the materials, rather than the absolute densities.

In summary, it should be noted that each situation described above is generally characterized by large volumes, lack of absorbing impurities, and/or the presence of very selective materials. These are conditions generally not applicable to shipping packages. Furthermore, any organization for which such conditions were applicable should have performed an independent assessment of its process operations.

ONGOING DEVELOPMENTS

Revisions to the fissile exemptions have been considered during the past several years as part of the normal revision process for the International Atomic Energy Agency transportation regulations. In September 1996, however, a licensee working with highly enriched uranium and beryllium oxide notified the Nuclear Regulatory Commission (NRC) of calculational examples in which criticality was possible even though the limits for fissile exemption were satisfied. (This was representative of Concentration Limit-Low Absorption Moderation, as discussed above.)

As a result of this notification, the various U.S. regulatory agencies—the NRC, Department of Energy, and Department of Transportation—are re-examining the fissile exemptions to assess if further limitations are warranted. A number of options are currently being examined, including the need to issue a change in the fissile exempt rules. Such changes might, for example, prohibit a

fissile exempt status for packages that contain certain moderating materials and/or limit the total fissile material in a consignment of fissile material packages.

Follow-on developments, especially as they affect shipments by the Department of Energy, will be presented.

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